Design Considerations for a Knowledge Graph: the WATRIMed use case

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\textbf{Healthcare of the Future}
5 April 2019, Biel/Bienne, Switzerland
Traditional Medicine (TM) is the oldest form of healthcare delivery.

The World Health Organization (WHO) estimates that as much as 80% of the population uses it in Africa.

Many reasons for that include:

- Inaccessibility, unaffordability, or unavailability of conventional health care services and medicines.
- Most people are underserved and mostly illiterate rural people.
- The distribution of products is limited by the low density of pharmaceutical personnel and/or medical infrastructures.
Context

➔ The 2014-2023 strategic plan of the WHO seeks to promote the safe and effective use of TM by regulating and integrating TM products, practitioners and practice into the formal health systems.

➔ West African Health Organisation (WAHO) has given priority to traditional medicine since 2007

 › important action item is the standardisation of descriptions of herbal and traditional medicines

 › Launch of the West African pharmacopeia in 2013
Increasing consensus that medical knowledge representation (KR) should use shareable standards for enabling computational support of data management.

ATM knowledge is mostly tacit and therefore largely shared in an informal manner and disseminated orally with the risk to lose or alter crucial medical information.

Medical KR formalisms are especially challenged in domains like TM that occupy a rather marginal position in the medical knowledge representation ecosystem.

➡️ Need for TM formalisation and digitizing
A early work in 2013

Engineering Applications of Artificial Intelligence
Volume 26, Issue 4, April 2013, Pages 1348-1365

Conceptual graph-based knowledge representation for supporting reasoning in African traditional medicine

Bernard Kamsu-Foguem, Gayo Diallo, Clovis Foguem

Abstract

Although African patients use both conventional or modern and traditional healthcare simultaneously, it has been proven that 80% of people rely on African traditional medicine (ATM). ATM includes medical activities stemming from practices, customs and traditions which were integral to the distinctive African cultures. It is based mainly on the oral transfer of knowledge, with the risk of losing critical knowledge. Moreover, practices differ according to the regions and the availability of medicinal plants. Therefore, it is necessary to compile tacit, disseminated and complex knowledge from various Tradi-Practitioners (TP) in order to determine interesting patterns for treating a given disease. Knowledge engineering methods for traditional medicine are useful to model suitably complex information needs, formalize knowledge of domain experts and highlight the effective practices for their integration to conventional medicine. The work
WATRIMED: West African Herbal-based Traditional Knowledge Graph

➔ Objectives

- Bringing West African TM to the digital world thanks to the use of state-of-the-art, flexible and shareable KR approach
- Helping to establish bridges with conventional medicine where necessary
- Contributing to preserve secular knowledge and help for more safe TM usage
- Offering a platform which can contribute enabling phytovigilance activity
WATRIMed: Overall Approach
### Formulations de plantes médicinales

**PALUDISME**

<table>
<thead>
<tr>
<th>R.</th>
<th>Cryptopelis sanguinolenta (racine)</th>
<th>40 g antipaludique</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Moringa oleifera (feuilles)</td>
<td>20 g antioxydant, stimulant du système immunitaire</td>
</tr>
<tr>
<td></td>
<td>Cymbopogon citratus (feuilles)</td>
<td>20 g fèbrifuge</td>
</tr>
<tr>
<td></td>
<td>Khaya senegalensis (écorce interne)</td>
<td>20 g antianémique</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100 g</td>
</tr>
</tbody>
</table>

**Décoction:** 100 g de mélange en poudre, dans 2500 ml d'eau, faire bouillir pendant 15 minutes. Réduire le volume à 2500 ml

**Posologie:** prendre 1 - 2 tasses à thé (150-300 ml) deux fois par jour pendant 5 jours.

**Teinture:** à 100 g de mélange en poudre, ajouter 500 ml (40-60%) pendant 8-14 jours et filtrer. Prendre 30-36 ml (2-4 cuillerées à soupe) deux fois par jour.

**Thé/infusion:** infuser 6-12 g de mélange en poudre, dans l'eau bouillante pendant 5-10 minutes. Prendre deux fois par jour.

**Effets indésirables:** Peut entraîner une séduction et une réduction du nombre de spermatozoïdes chez certains patients de sexe masculin.

**Contre-indications:** Grossesse et allaitement, ulcére gastrique et polype de plus de 12 ans.

#### Indications

1. **R.** Cryptopelis sanguinolenta (racine) 40 g antipaludique
2. Moringa oleifera (feuilles) 15 g antioxydant, stimulant du système immunitaire
3. Cymbopogon citratus (feuilles) 15 g fèbrifuge
4. Khaya senegalensis (écorce interne) 15 g antianémique
   * Cassia alata (feuilles) 15 g laxatif
   * 100 g

* si le paludisme est accompagné de constipation

**Décoction:** 100 g de mélange en poudre, dans 2500 ml d'eau, faire bouillir pendant 15 minutes. Réduire le volume à 2500 ml

**Posologie:** prendre 1 - 2 tasses à thé (150-300 ml) deux fois par jour pendant 5 jours.

**Teinture:** à 100 g de mélange en poudre, ajouter 500 ml (40-60%) d'alcool. Laisser reposer pendant 8-14 jours et filtrer. Prendre 30-36 ml (2-4 cuillerées à soupe) deux fois par jour.

**Thé/infusion:** infuser 6-12 g de mélange en poudre, dans l'eau bouillante pendant 5-10 minutes. Prendre deux fois par jour.

**Effets indésirables:** Peut entraîner une séduction et une réduction du nombre de spermatozoïdes chez certains patients. Une dose excessive peut provoquer la diarrhée.

**Contre-indications:** Grossesse et allaitement, ulcére gastrique et enfant de moins de 12 ans.
External publicly available knowledge bases

- DBpedia
- PubChem
- STITCH
- WIKIDATA
- GeoNames
- IPNI
- YAGO

18 avril 2019 WATRIMED
How can we then integrate WATRIMed with other related Ontologies?

➔ Foundational ontologies can ensure the interoperability between different ontologies
➔ They contain very general categories, which are common for a set of domains
➔ We have chosen BioTopLite2 upper level Ontology
  › A lightweight version of BioTop
  › BioTop has been launched in 2006
  › BioTop itself inherits from Basic Formal Ontology (BFO)
Mapping HTM Ontology with an Upper-Level Ontology

➔ Upper classes and relations of BioTopLite2

<table>
<thead>
<tr>
<th>Disposition</th>
<th>Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>Quality</td>
</tr>
<tr>
<td>Immaterial Object</td>
<td>Role</td>
</tr>
<tr>
<td>Information Object</td>
<td>Temporal Region</td>
</tr>
<tr>
<td>Material Object</td>
<td>Value Region</td>
</tr>
</tbody>
</table>

➔ Upper classes and relations of WATRIMED

<table>
<thead>
<tr>
<th>Adverse Reaction</th>
<th>Therapeutic Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical</td>
<td>Plant Part</td>
</tr>
<tr>
<td>Component</td>
<td>Usage Precaution</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>Formulation</td>
</tr>
<tr>
<td>Medicinal Plant</td>
<td>Vernacular Name</td>
</tr>
<tr>
<td>Recipe</td>
<td>ContraIndication</td>
</tr>
</tbody>
</table>

2

<table>
<thead>
<tr>
<th>at some time</th>
<th>includes</th>
</tr>
</thead>
<tbody>
<tr>
<td>causes</td>
<td>precedes</td>
</tr>
<tr>
<td>has condition</td>
<td>projects onto</td>
</tr>
<tr>
<td>has participant</td>
<td>represents</td>
</tr>
</tbody>
</table>

3

4

*dispositional properties and non categorial ones

The mapping process was done for all the concepts in (3) and categorial relations
Results: the TradiMed database and the HTM Ontology

- TradiMed: a relational database hosted under a PostgreSQL server with 25 tables totaling 3544 tuples.

- The HTM Ontology: 556 concepts organized around MedicinalPlant, with 75 properties (57 object properties and 18 data properties).

**Component Size**:
- Medicinal Plants: 143
- Countries: 16
- Therapeutic Indications: 110
- Contraindications: 148
- Local Dialects: 122
- Traditional Medicine Recipes: 108
- Chemical Compounds: 179
- Plant Parts: 34

**1.Rx — http://watrimed.org/ATM#1.Rx**

Class hierarchy: 1.Rx

Annotations: 1.Rx

Description: 1.Rx

SubClass Of (Anonymous Ancestor)
Definition of the 1.Rx, a Recipe which is a Therapeutic Mixture

Définition of Moyatabél, the Vernacular name in Burkina Faso’s Fulfuldé of Alstonia_Boonei
Results: Link to external available Knowledge Bases

Additional information with rdfs:seeAlso

MedicinalPlant → DBpedia

Vocabulary → IPNI

ChemicalComponent → WIKIDATA

MedicinalPlant → IPNI

Vocabulary → WIKIDATA

ChemicalComponent → STITCH

TheurapeuticIndication → YAGO

ContraIndication → YAGO

WIKIDATA → STITCH

PubChem
Results: The Mapping to the BioTopLite2 Upper Ontology

Simple SubClass mapping

- wat:Adverse Reaction under btl2:process
- wat:Therapeutic Mixture under btl2:compound of collective material entities

Complex SubClass mapping

- wat:Acacia_nilotica SubClassOf
  - (hasPart some Arabic_acid)
  - and (hasPart some Chlorogenic_acid)
  - and (hasPart some Gallic_acid)
  - and (hasPart some Leucoanthocyanidin)
  - and (hasPart some 3-beta-acetoxy-17-beta-hydroxyandrost-5-ene)
Conclusion

➔ Current situation of WATRIMed
  › A knowledge graph with mappings with external publicly available knowledge bases and the BioTopLite Upper-Level Ontology
  › The core model contains 556 concepts including the description of 143 Medicinal Plants, 108 Recipes and 110 diseases
  › More than 30,000 facts (triplets) in the Graph
  › Available at http://watrimed.org/wul.html

➔ Ongoing and Future Work
  › An expert on pharmaceutical products is validating the content of the KG according to the scientific literature
  › Enriching the graph with additional resources (e.g., target genes)
  › Herbs-Drugs interactions identification is planned, using Artificial Neural Networks (kANNA H2020 Marie-Curie Postdoc of G. Bordea, from April 2019)
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